Developing Performance Engineered Concrete Paving Mixtures PP 84-17

Super Air Meter

A Review

LafargeHolcim

Super Air Meter

PP 84 Performance Engineered Mixtures (Provisional)

- Covers the test methods and values for concrete pavement mixtures using alternative performance characteristics for acceptance.
  - Concrete performance in paving and structures needs to improve!
    - The super air meter measures one of the "alternate" performance characteristics
    - TP 118 is provisional
    - It is still being investigated for acceptance by the industry

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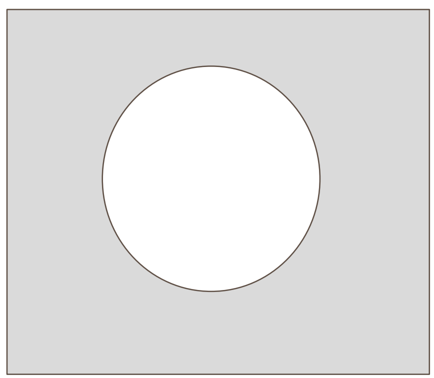
The following DOTs are supporting the SAM!

- OKDOT
- KSDOT
- NEDOT
- IADOT
- MNDOT
- CODOT
- CNDOT
- PennDOT
- NJDOT
- NYSDOT
- ILDOT
- MIDOT
- WIDOT

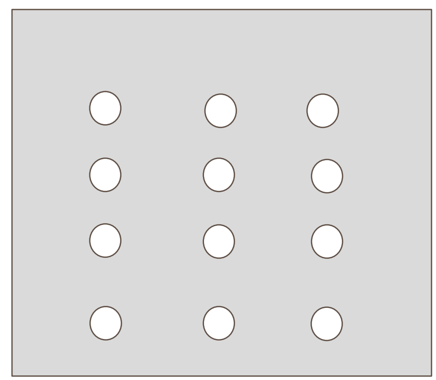
Super Air Meter (from Tyler Ley‘s Presention)

Air-entrained bubbles are the key to freeze-thaw resistance

- Total air volume ≠ freeze-thaw performance
  - Smaller bubbles are more effective than larger ones
  - Large bubbles are ineffective!
    - More buoyant, dissipate faster
    - If the volume of air is equal in both scenarios below, Scenario B is better



Scenario A

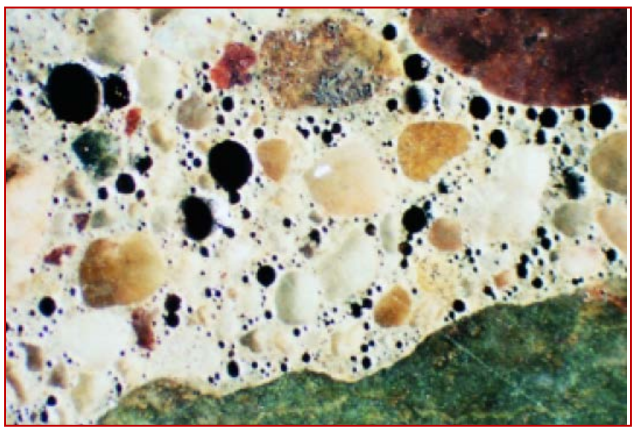


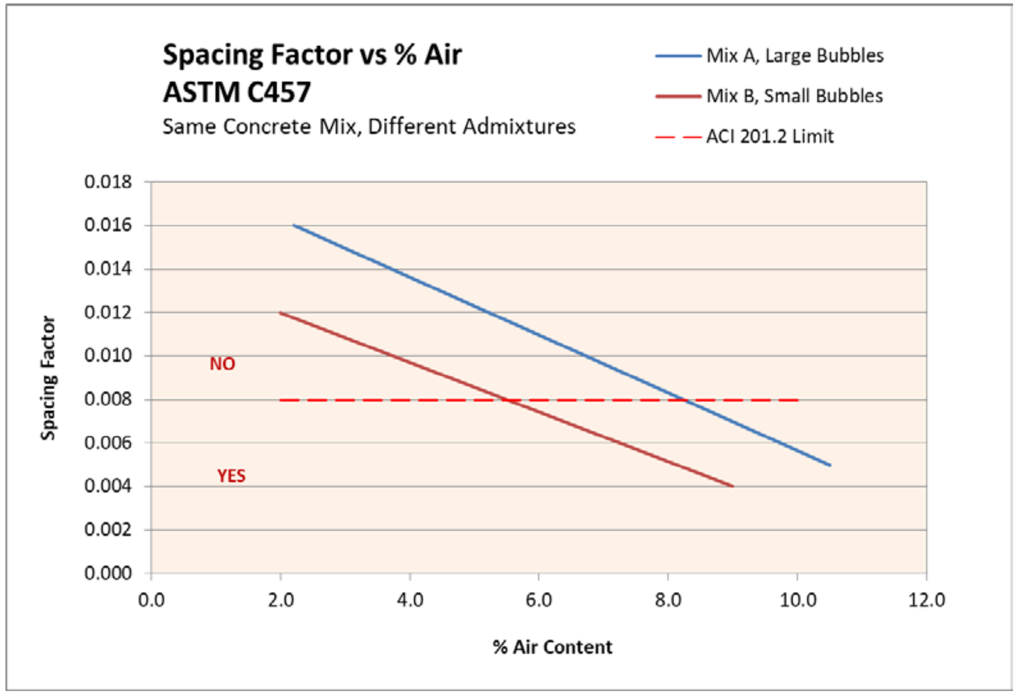
Scenario B

Super Air Meter (from Tyler Ley's Presention)

ASTM C457 – Microscopical Determination of Parameters of the Air-Void System in Hardened Concrete

- Spacing Factor, $\bar{L}$, is the most significant indicator of durability of the paste
  - Roughly the distance water needs to travel to get to a bubble
  - ~ 0.004" to 0.008"





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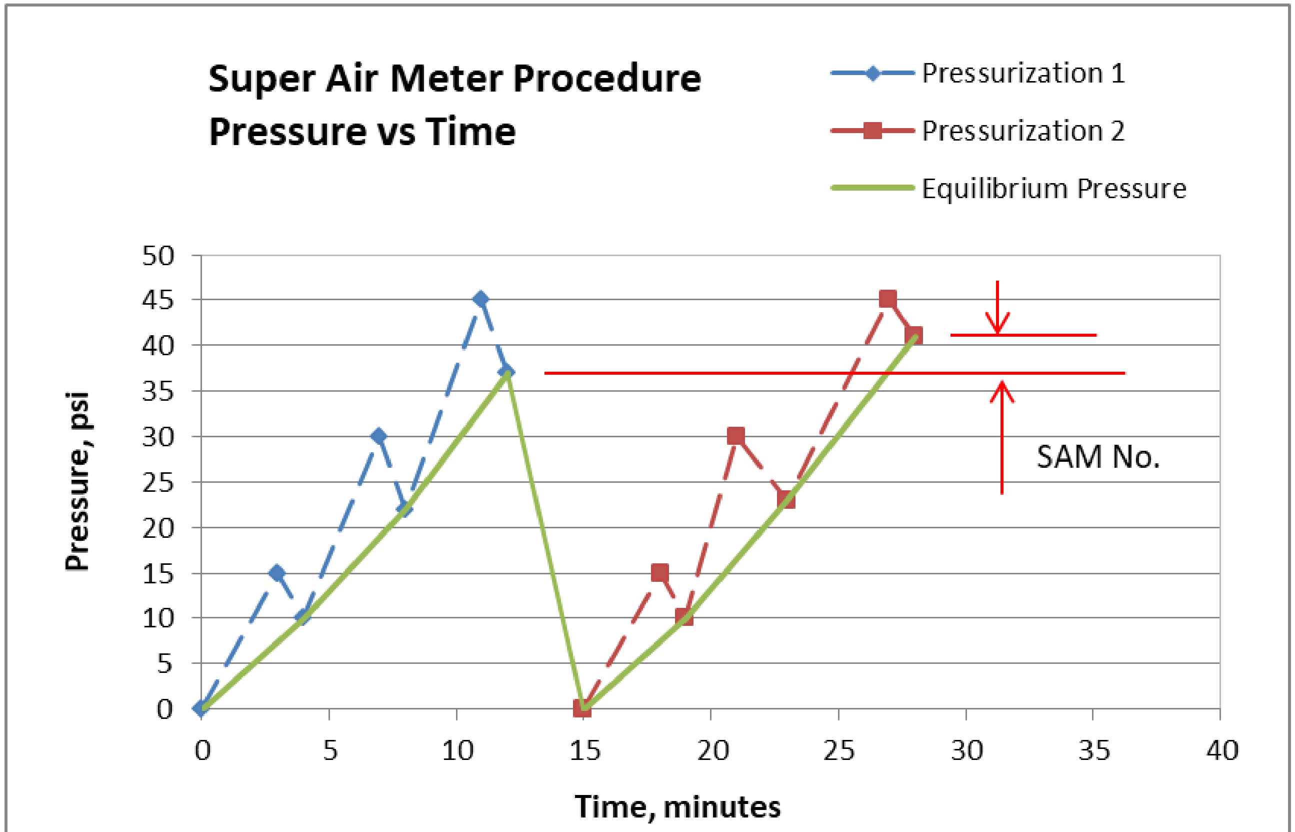
Targeting % Air is not enough to ensure F-T Durability! Need to know the size of the bubbles!

Test Procedure



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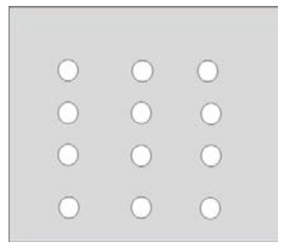
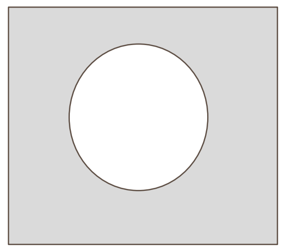
Theory

- Liquid under pressure that is saturated with air, will stop accepting more air, preventing dissolution
  - Systems with low spacing factors (< 0.008") rapidly saturate surrounding liquid, more bubbles remain
  - Systems with high spacing factors will not saturate liquid, more bubbles dissolve
    - Bubbles in a high (bad) spacing factor system almost entirely dissolve and do not reform when pressure is released



  - **High Spacing Factor (bad): high SAM number**
  - **Low Spacing Factor (good): low SAM number**



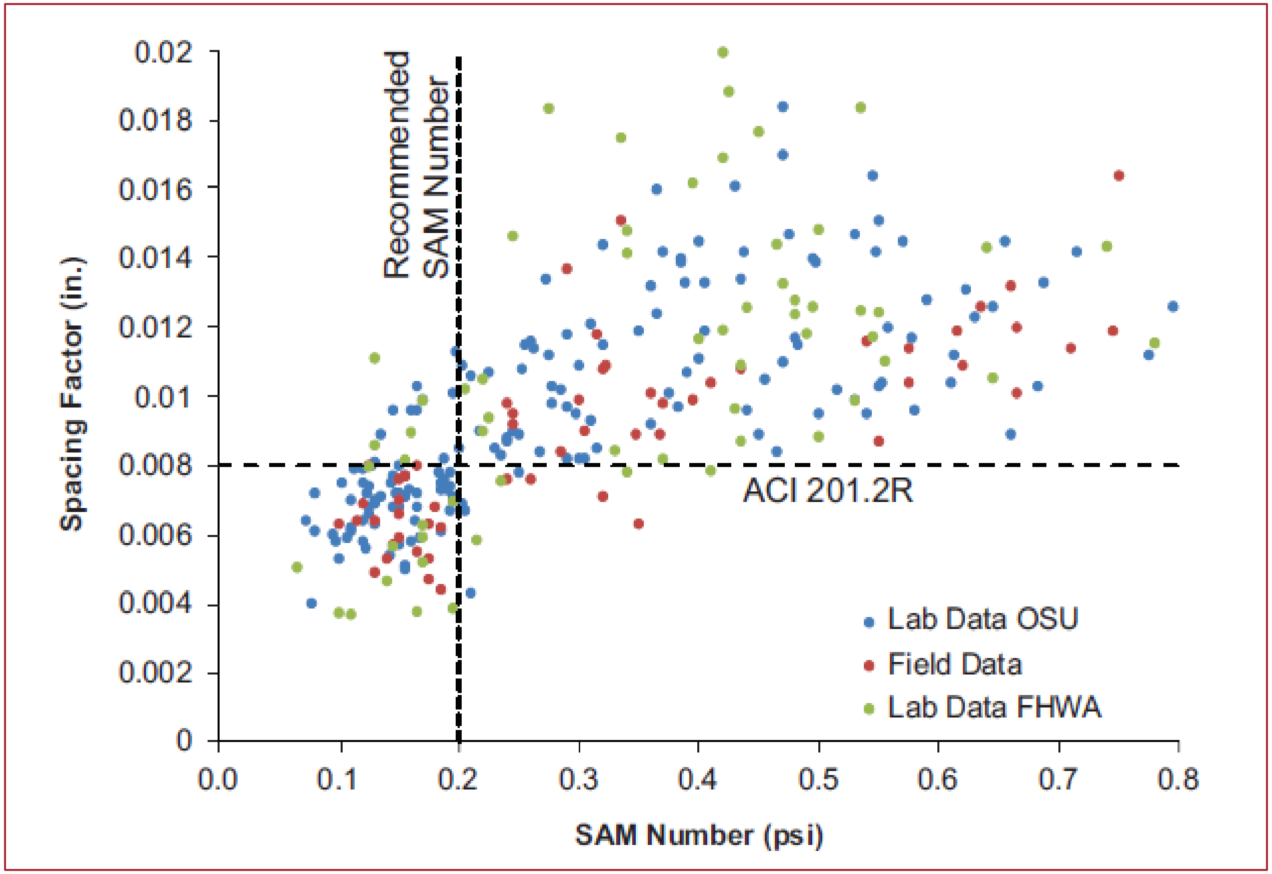
Super Air Meter (from Tyler Ley's Presention)

Lab & Field Data – SAM Number vs Spacing Factor

When SAM # < 0.20 and SF < 0.008"

- Lab data gives 92% "agreement"
- Field data gives 68% "agreement"

(i.e., when SAM # is below 0.2, SF is below 0.008" or when SAM # is above 0.2, SF is above 0.008")



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Precision & Accuracy

FHWA has asked the industry to evaluate the new testing methods proposed in PP 84 - 17

Precise but not Accurate

Accurate but not Precise

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LafargeHolcim Lab Testing Program

- Our lab testing program was conducted to determine the effects of changing variables on the SAM number
- To determine the relationship of the SAM number to:
  - i. air content
  - ii. spacing factor
  - iii. freeze/thaw durability
- The variables in this testing matrix were:
  - I. 6 different cements
  - II. 4-different air contents
  - III. 2 -different chemical admixtures
  - IV. 1-SCM Mix
  - V. All mixes contain 598 pcy total cementitious

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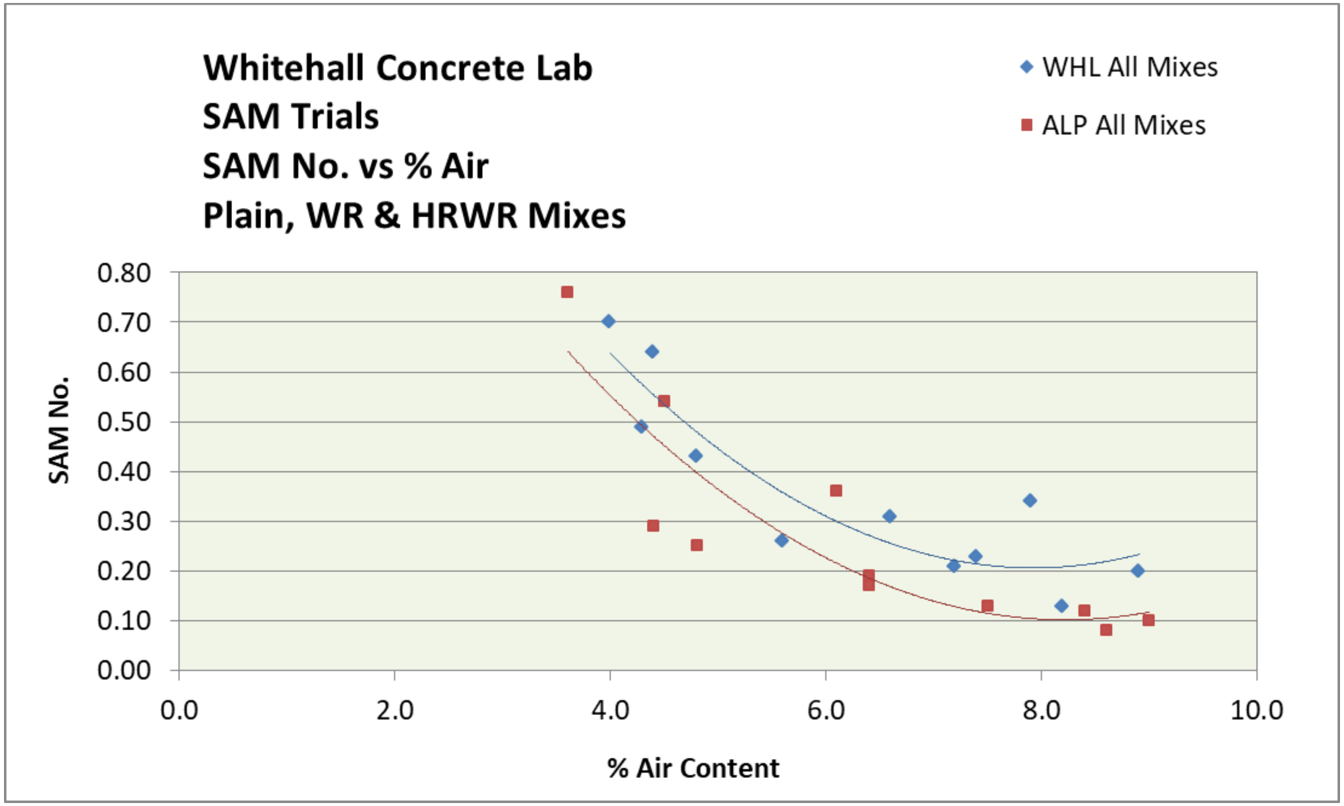
Whitehall Data – Whitehall T-I & Alpena T-I/II

Conclusions

- When comparing multiple mixes, SAM No. correlates moderately well with % air



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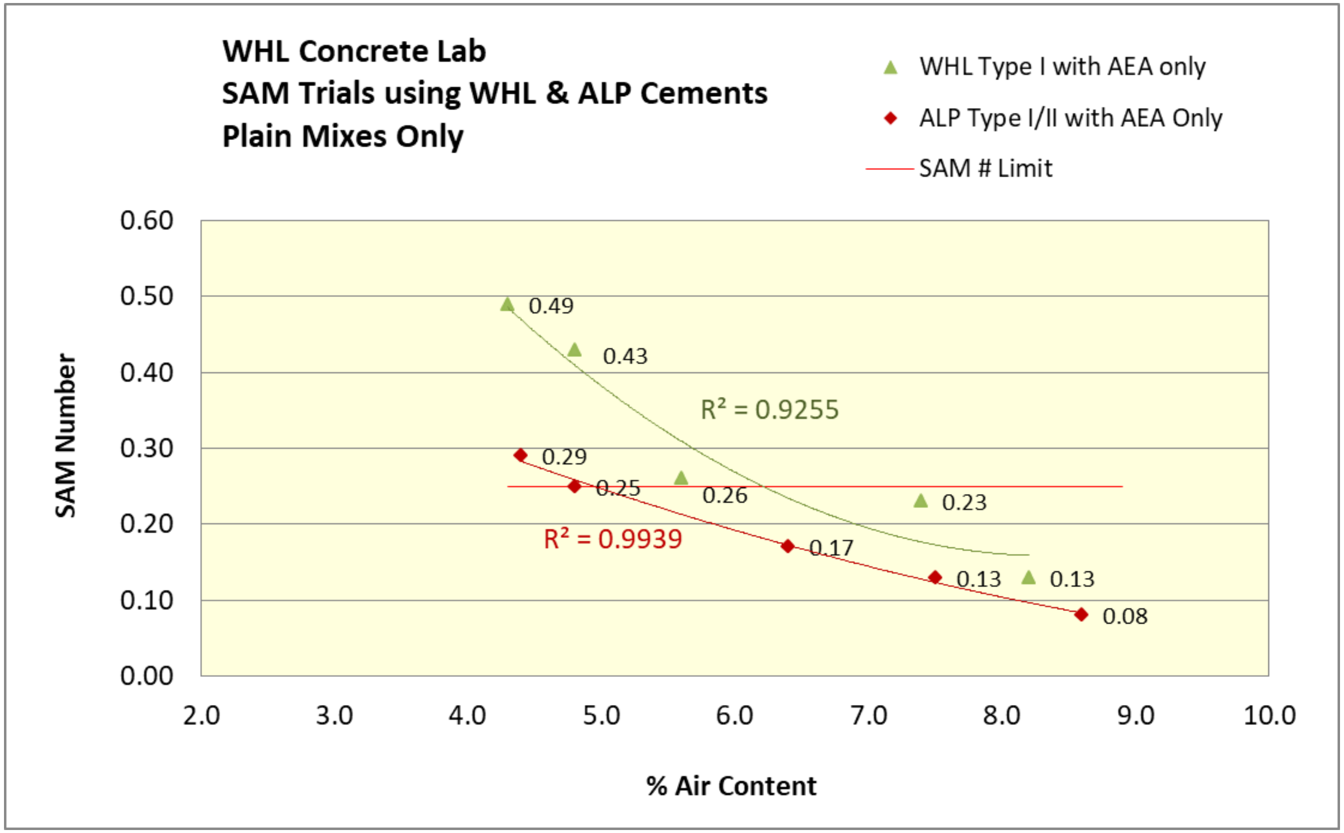
Whitehall Data – WHL Type I HA vs ALP Type I/II LA

Conclusions

- % Air correlates well with SAM Nos when data from one mix is considered
- SAM Nos are better (lower) with ALP cement
  - Low alkali?
- Higher dose of AEA required for low alkali cement



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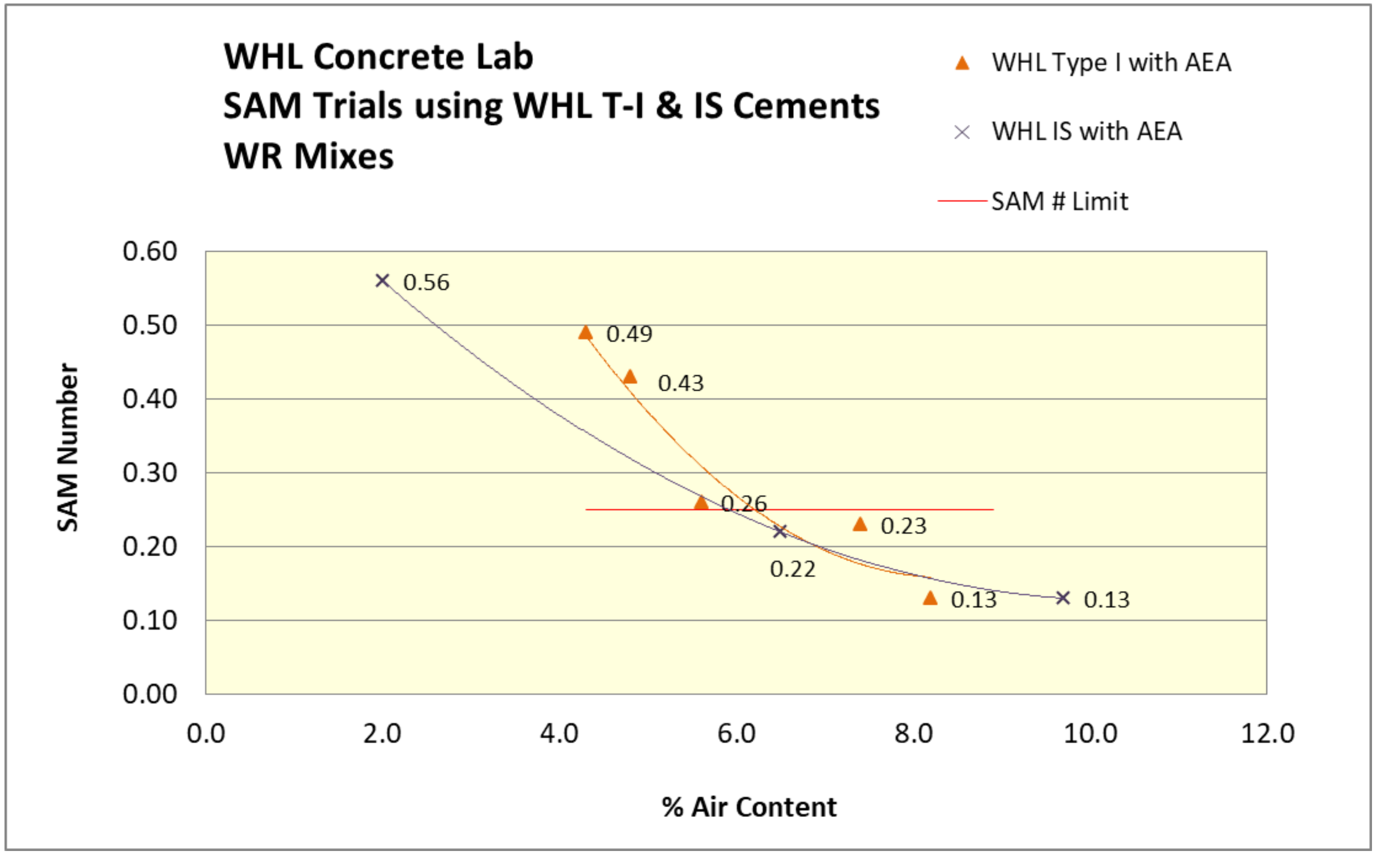
Whitehall Data – Type I vs Type IS(40)

Conclusions

- WHL Type IS(40) yields about the same SAM Nos compared to WHL T-I



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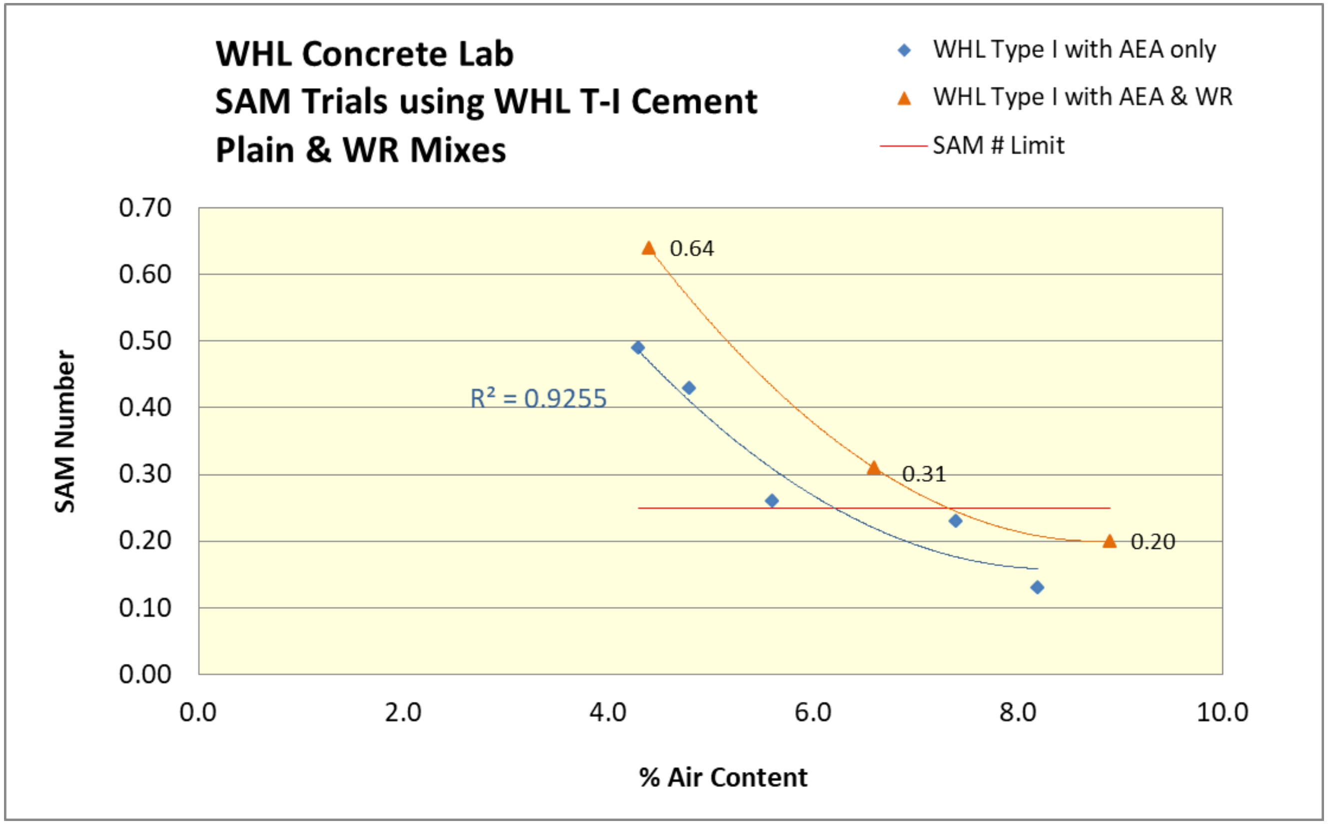
Whitehall Data – Admix Compatibility (Water Reducers)

Conclusions

- Mid-Range WR increases Sam Nos



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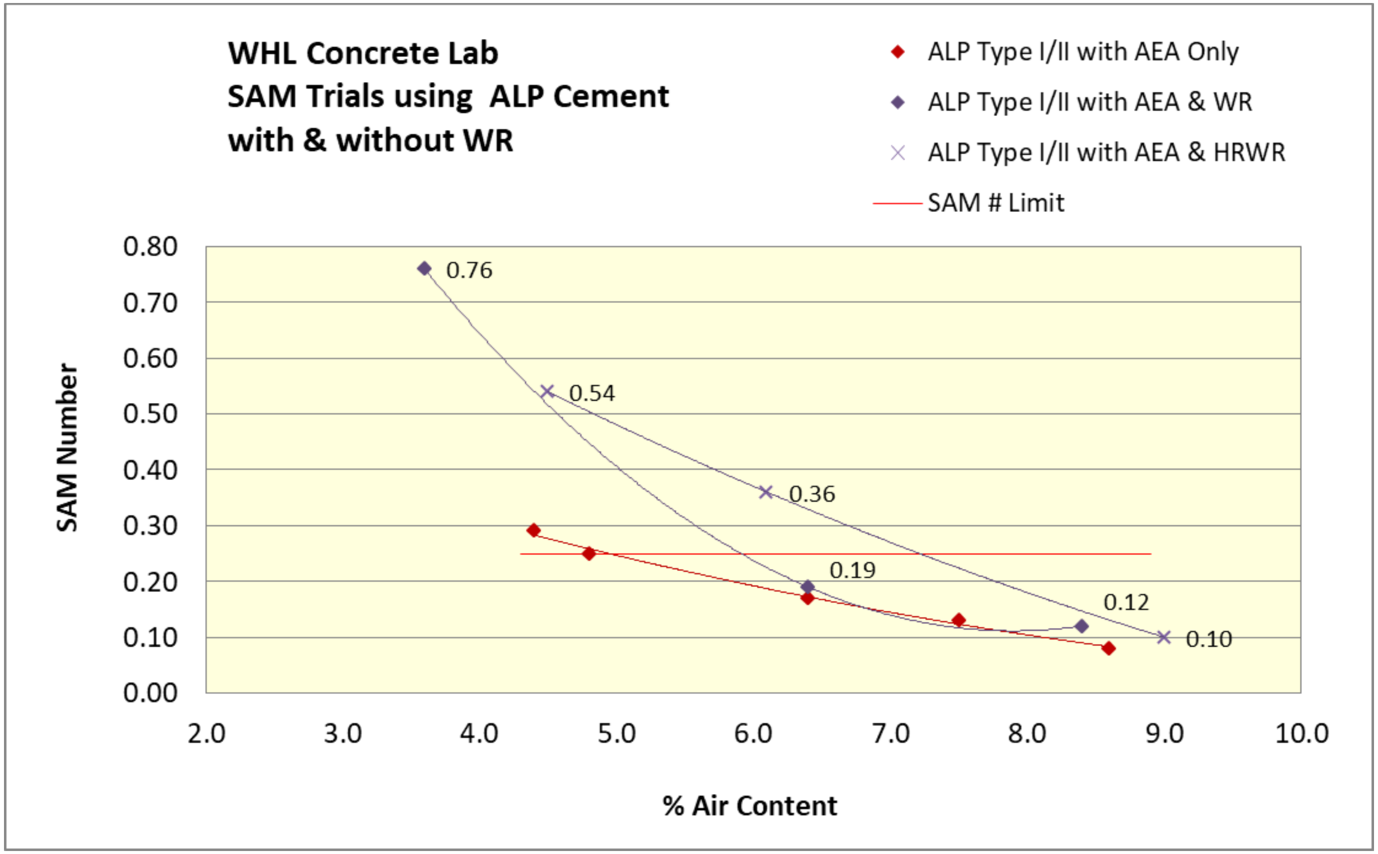
Whitehall Data – ALP T-I/II with WR & HRWR

Conclusions

- HRWR increases SAM Nos even more!



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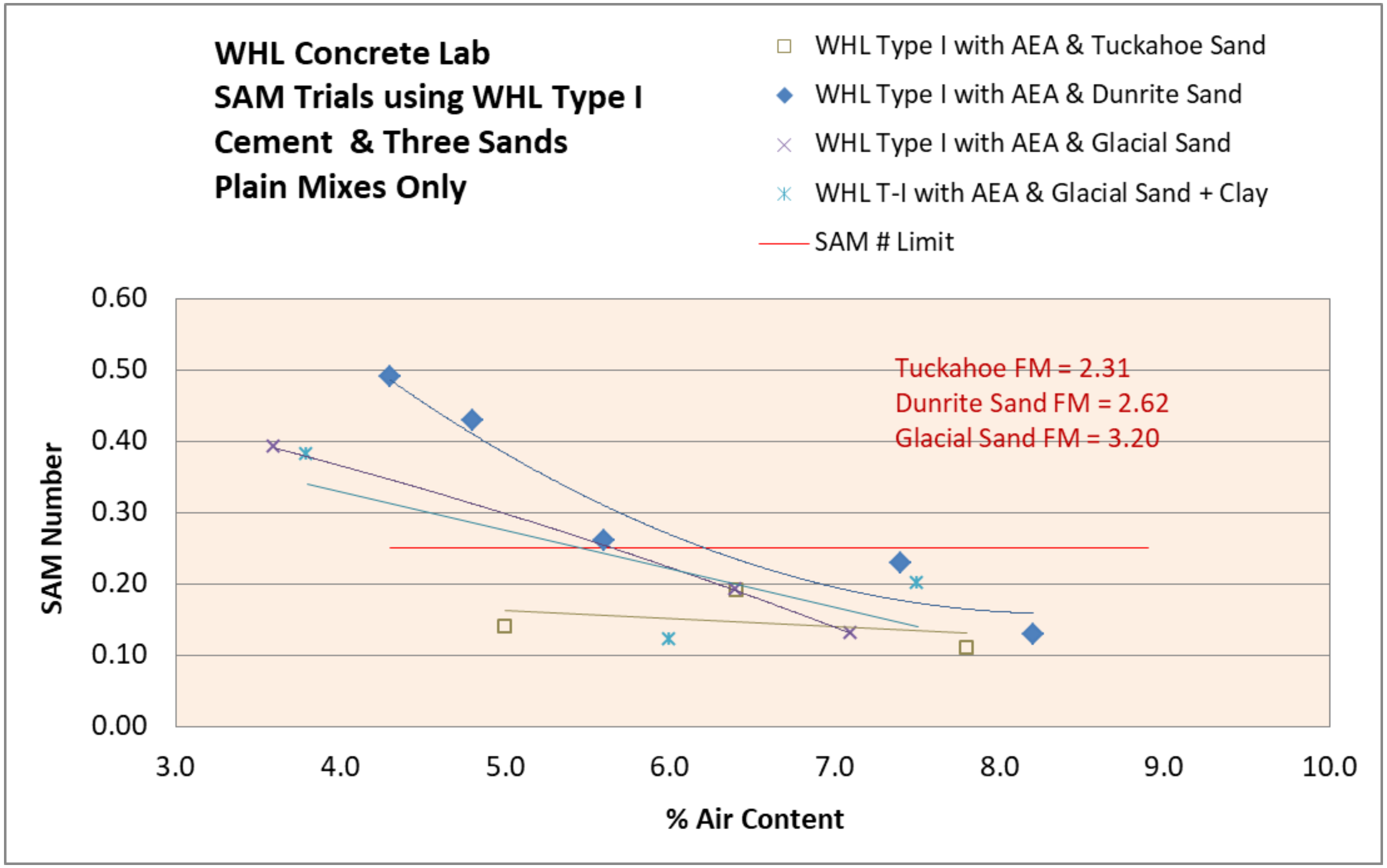
Whitehall Data – Fine Sand vs Coarse Sand

Conclusions

- Different sands can change the SAM Nos.



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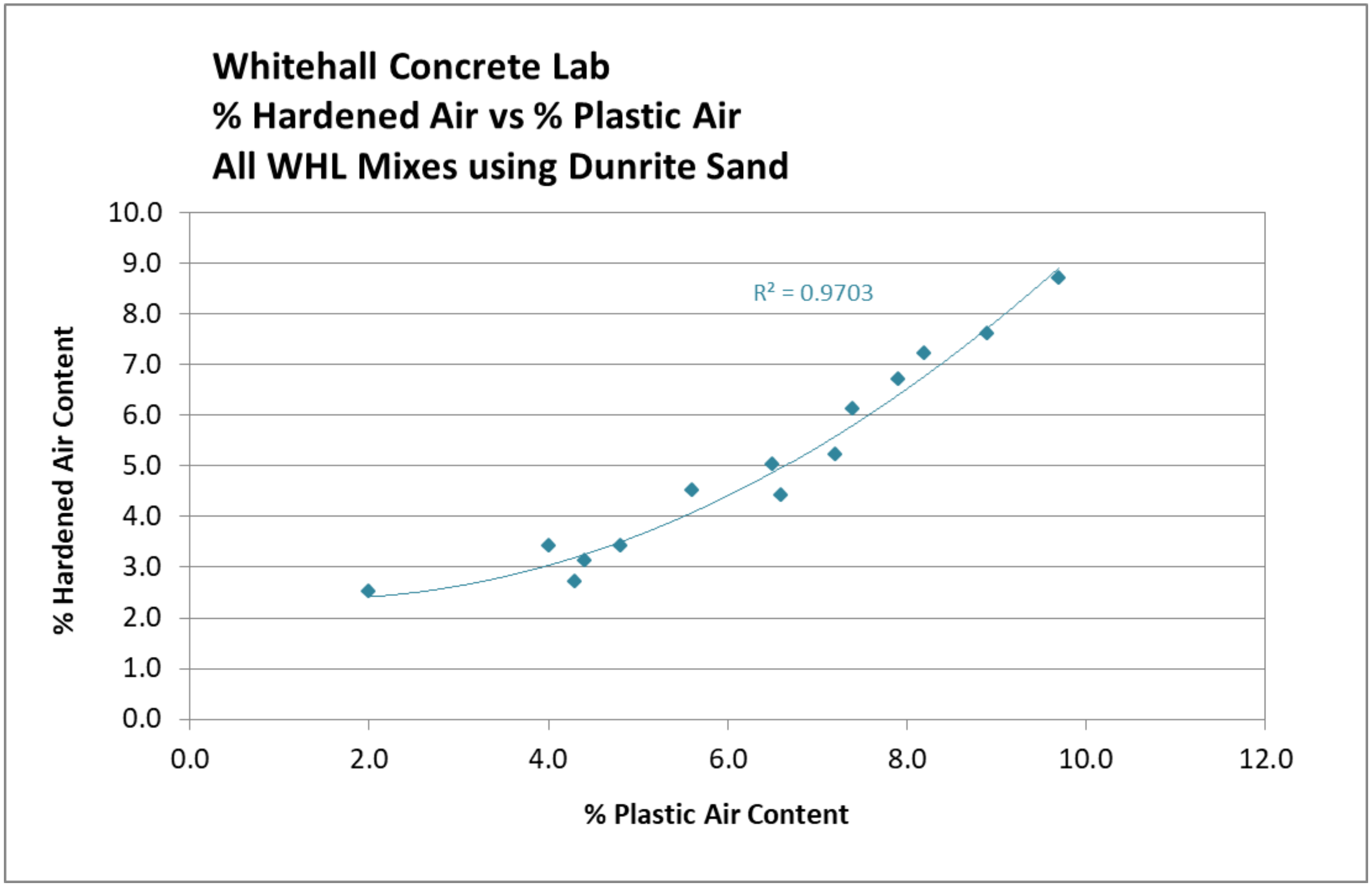
Linear Traverse – Hardened vs Plastic Air



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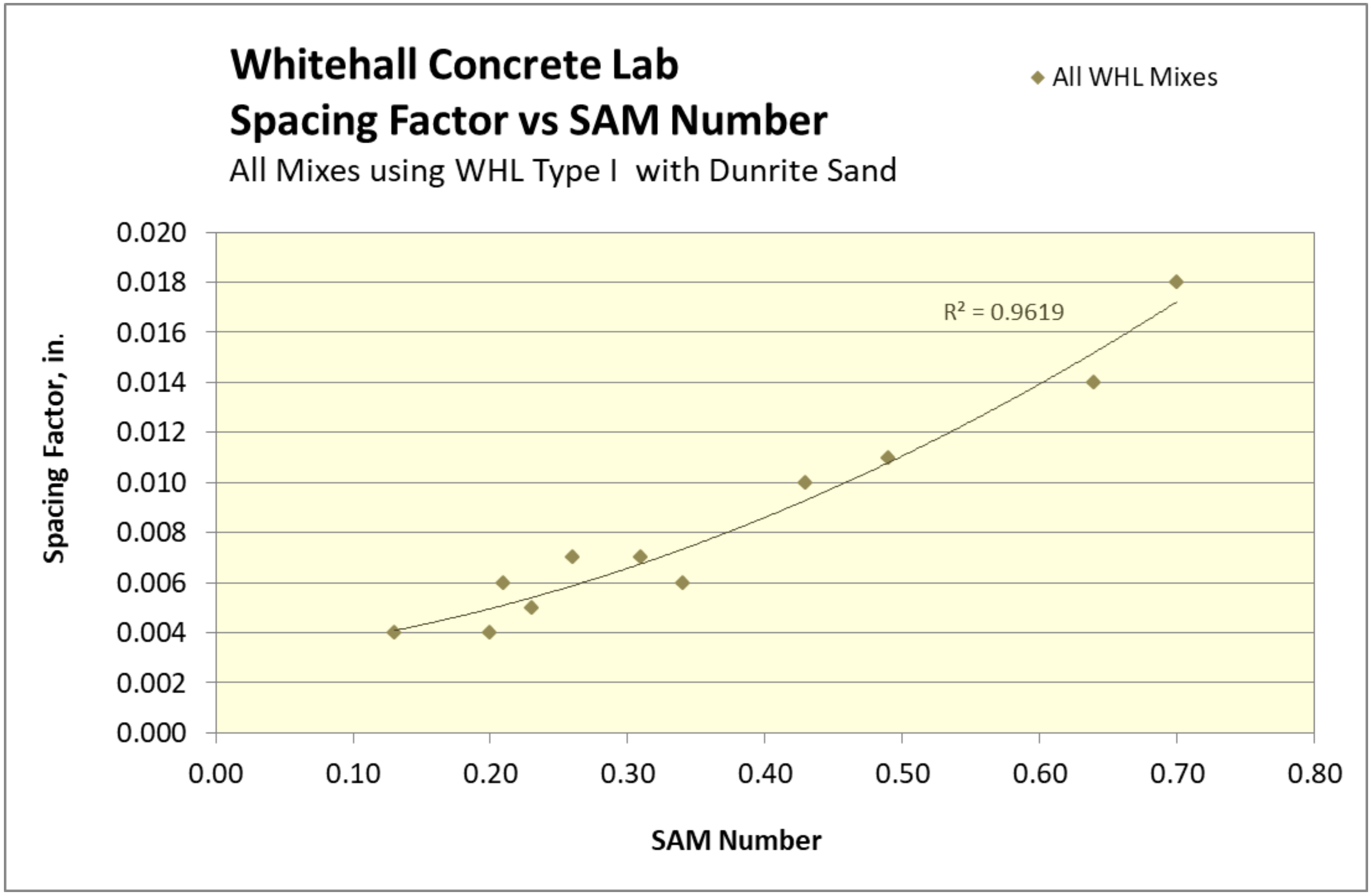
Spacing Factor vs SAM Number



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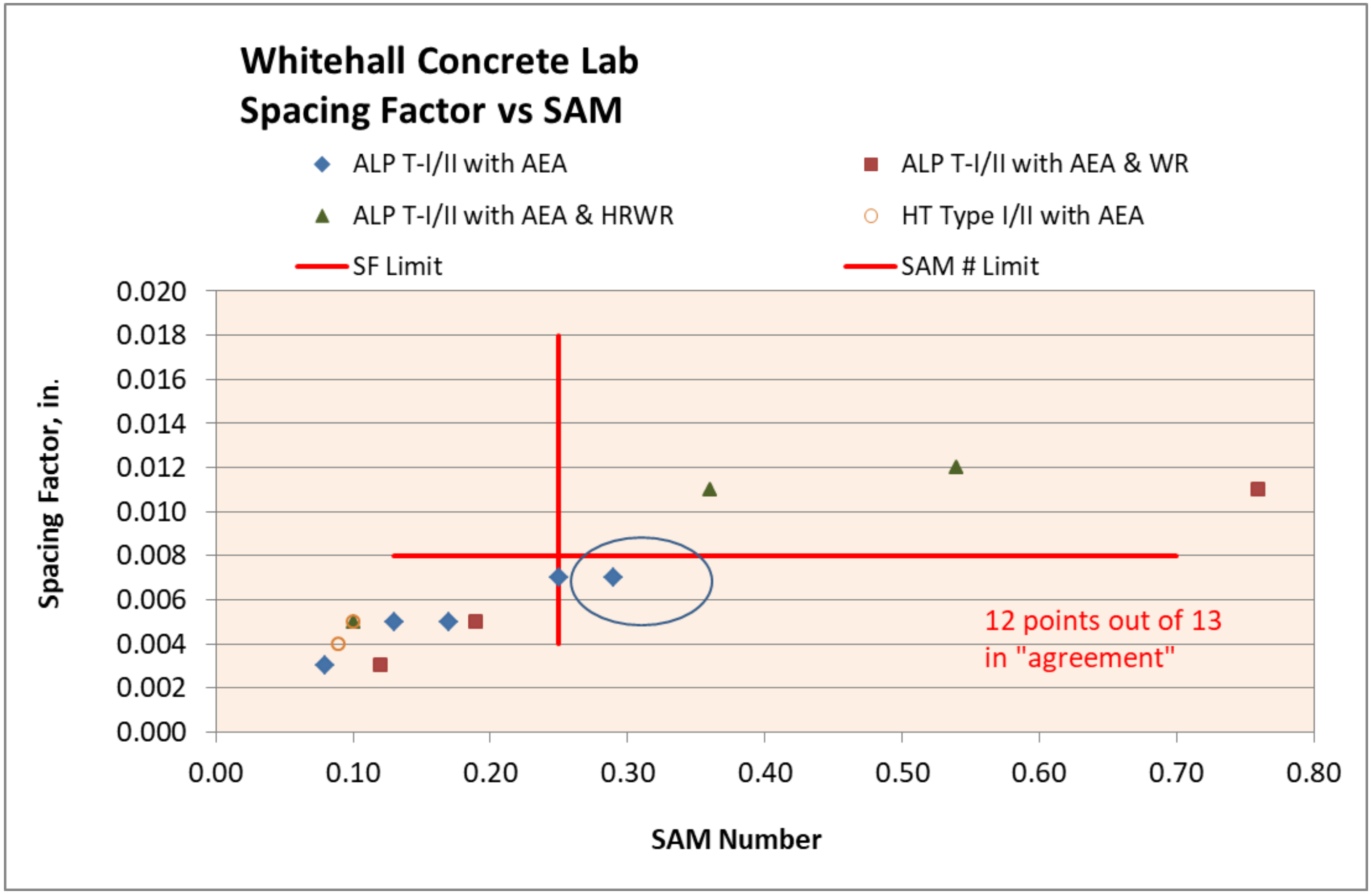
Spacing Factor vs SAM Number



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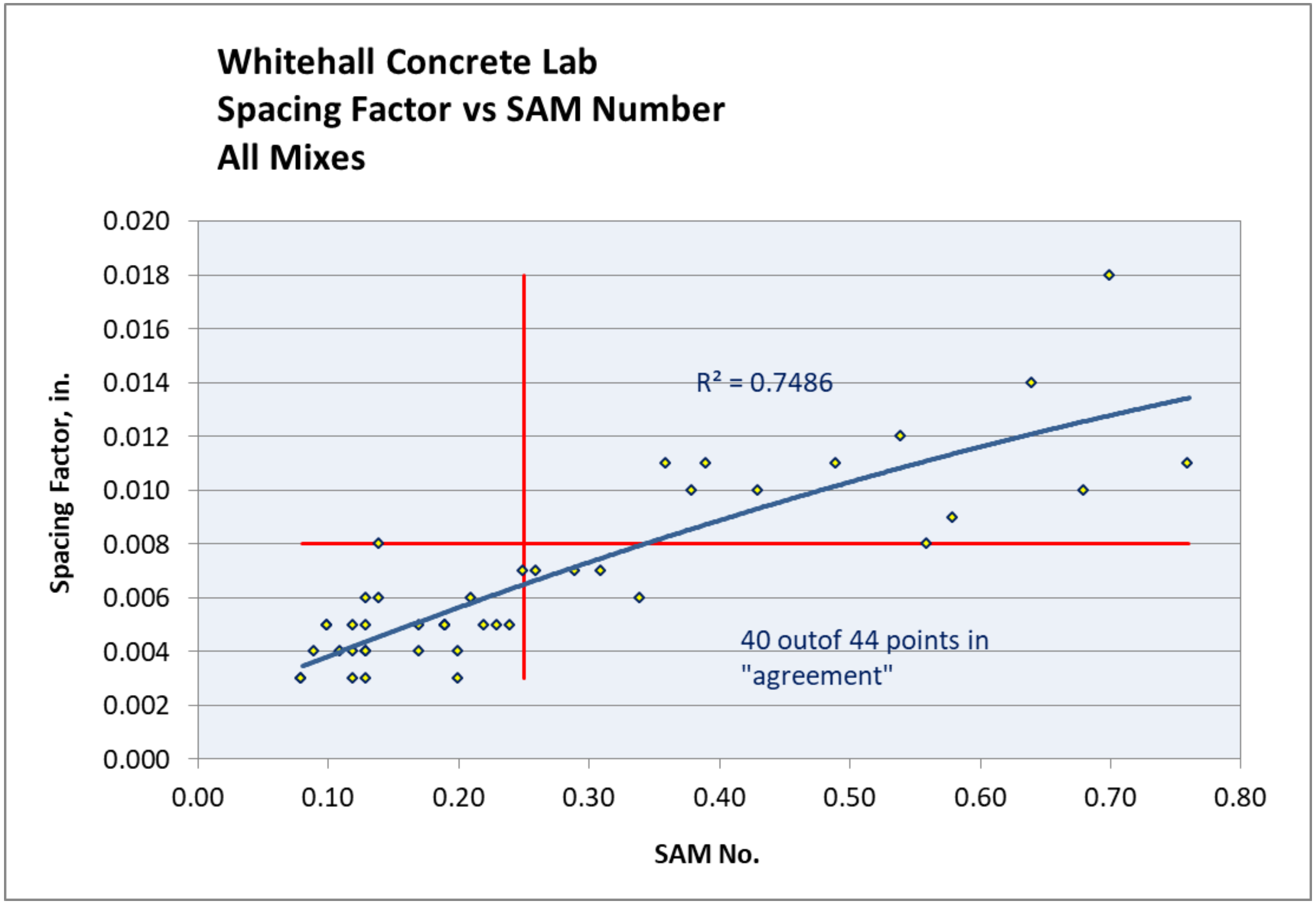
Spacing Factor vs SAM Number



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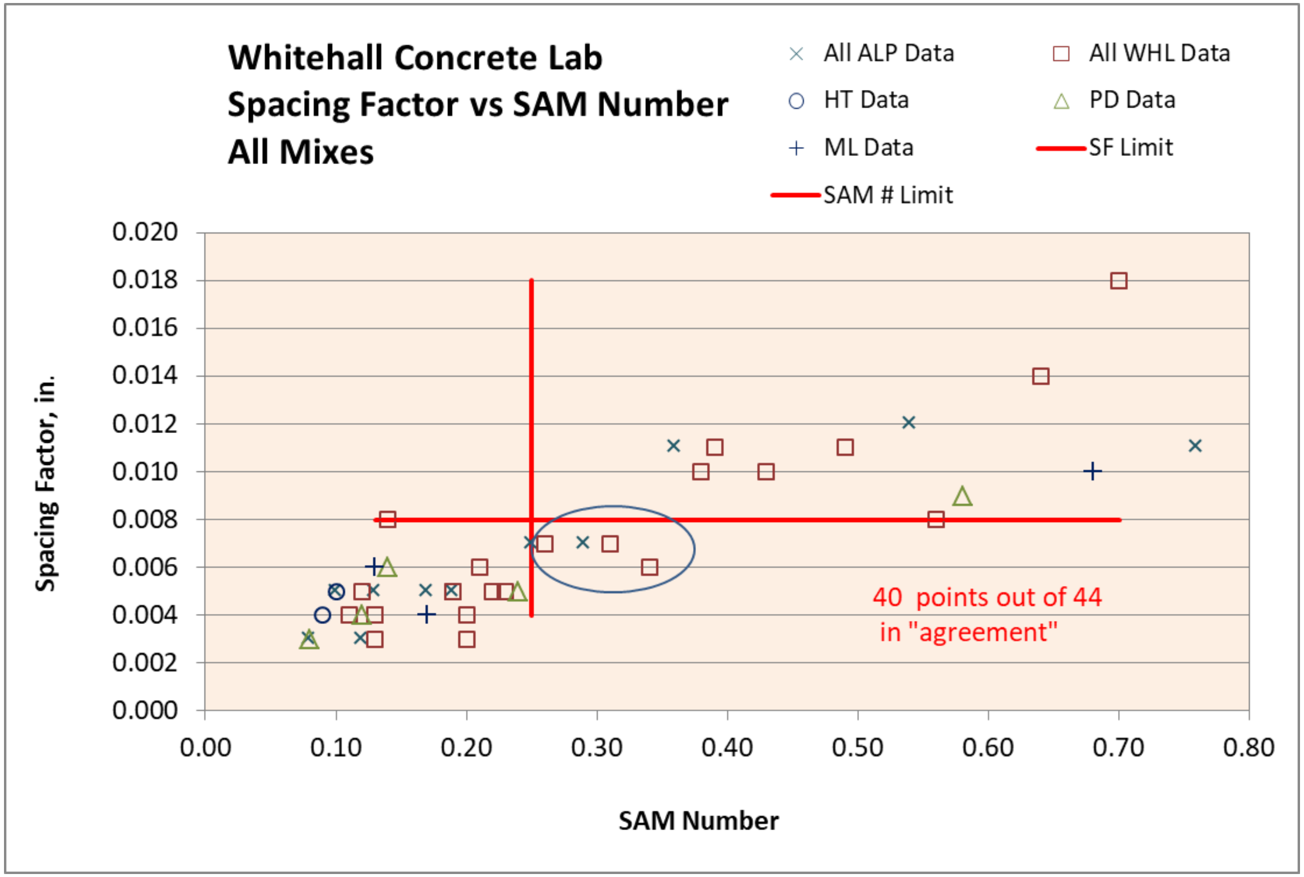
Spacing Factor vs SAM Number



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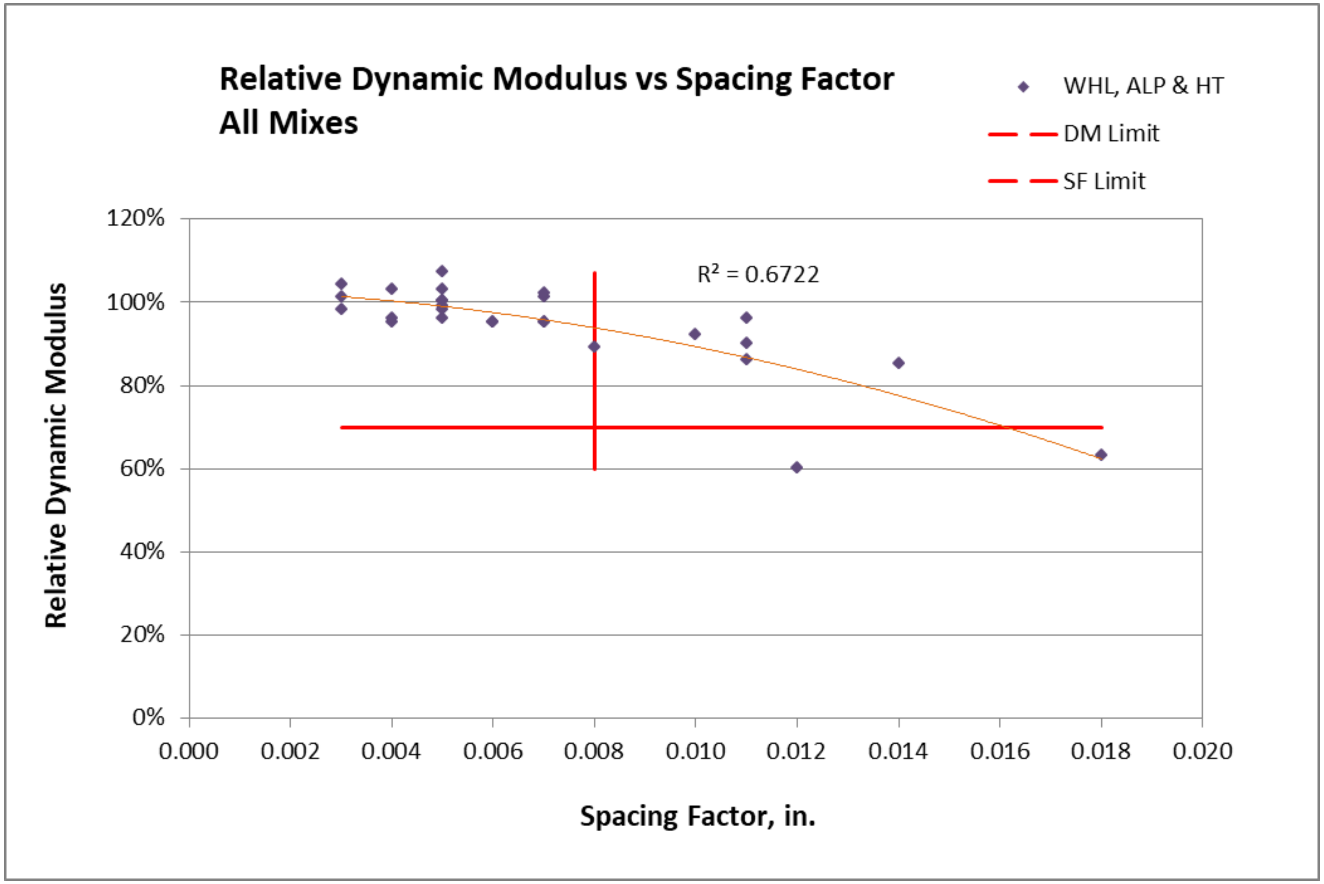
Dynamic Modulus – C666



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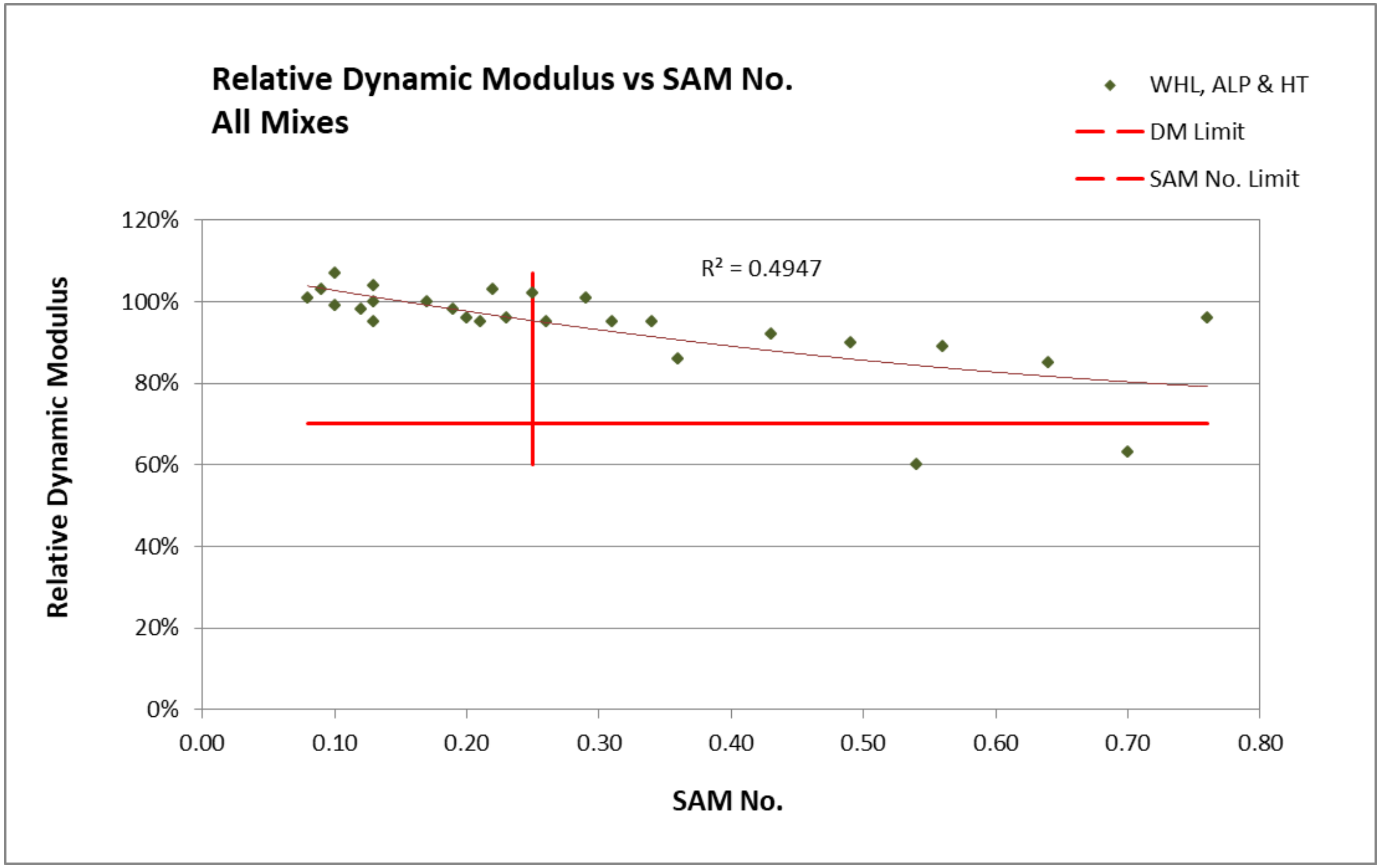
Dynamic Modulus – C666



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Conclusions

- In a controlled lab environment the SAM number correlates relatively well for a given set of materials to both air content and spacing factor
  - As you increase the variables in the mixes the correlation between the SAM number, air content and spacing factor is reduced
- 10% of the mixes had SAM Nos that contradicted the spacing factor
- The spacing factor is a better predictor of the Dynamic Modulus than the Sam No.
- All these conclusions are from lab testing and do not address any variations introduced in the field